Evaluation of In-flight Alertness Management Technology

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An objective approach for detecting the presence of drowsiness and fatigue on the flight deck was demonstrated in a full-mission simulation. Long, uneventful flights in modern aircraft are characterized by (1) extensive monitoring because of high levels of aircraft system automation, (2) physical inactivity, (3) a requirement to remain vigilant for low-frequency occurrences, (4) dim light levels, (5) steady background noise, (6) reduced social and cognitive interaction, and (7) limited environmental manipulations. Together these factors create a context in which underlying sleepiness is likely to manifest itself in the form of compromised vigilance, reduced alertness, and impaired performance. Flying at night while fatigued is further complicated by the fact that individuals are poor at judging their own level of sleepiness, often reporting high levels of alertness even though physiological measures may suggest extreme sleepiness.

A controlled cockpit simulator study was conducted to evaluate the feasibility and utility of an on-line, human-centered, objective monitoring technology for tracking alertness-drowsiness and to evaluate the effectiveness of fatigue-related feedback on the alertness, neurobehavioral performance, and behavior of flight crews during a simulated, long-haul, nighttime flight. The alertness-drowsiness monitoring technology used is based on the PERCLOS metric: the proportion of time subjects exhibit slow eye closures. This metric has been validated in the laboratory as being highly accurate in detecting drowsiness-induced performance lapses. In the past, however, eye closures have been scored subjectively by a human rater. In this study, we used a fully-automated, video-based system using infrared retinal reflectance to measure PERCLOS objectively. The automated PERCLOS system, developed by the Carnegie Mellon Research Institute, is shown in figure 1. In addition, the effects of feedback on subsequent alertness, neurobehavioral performance, and behavior were evaluated. Thus, this study was the first demonstration of the potential usefulness of an on-line, human-centered, objective monitoring technology capable of detecting reduced vigilance (hypovigilance) and providing feedback on the flight deck.

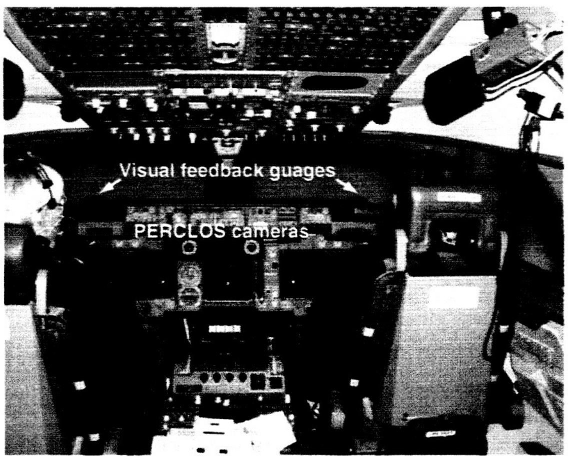

Fig. 1. Unobtrusive, on-line, automated, biobehaviorally based PERCLOS systems mounted in the cockpit of the Boeing 747-400 simulator.

Twelve two-man crews consisting of 28 healthy male adults familiar with glass cockpits, flew 6-hour, uneventful, nighttime flights in the Ames 747-400 FAA-certified, Level D flight simulator. Each flight was divided into four counterbalanced segments. In half of these segments, PERCLOS feedback was available on a light emitting diode (LED) display by indicator lights that illuminated as eye closure durations increased, or by a human voice message. The first-generation PERCLOS system implemented in the study consisted of online, computer analysis of video images of the subject's eyes using small cameras with infrared illumination sources mounted on the flight deck (fig. 2). Measures of psychomotor

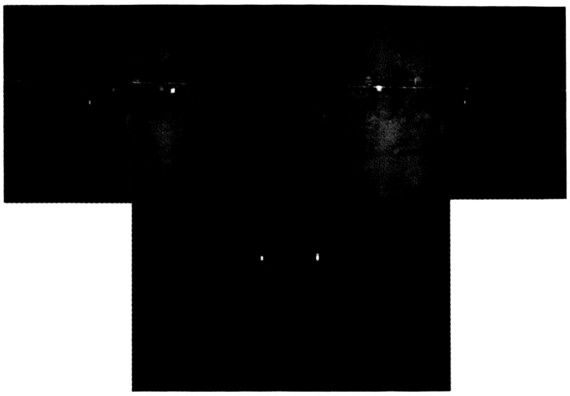

Fig. 2. The automated PERCLOS system captures two infrared images of the eye using a small camera with associated optics mounted in the flight deck. The two images are processed and reduced to a single image which is evaluated online for degree of eyelid closure.

vigilance performance, subjective sleepiness, continuous brain wave activity (electroencephalography, EEG), and continuous eye movement activity (electrooculography, EOG) were collected throughout the flight.

A PERCLOS-based alertness monitoring technology on the flight deck has potential as an on-line noninvasive alertness system for pilots who may encounter challenges in high homeostatic drive and circadian rhythm disruption. An on-line, human-centered, objective monitoring technology may be used as a backup for crew members who have integrated in-flight napping or activity break policies in their standard operating procedures. This type of technology can also potentially be implemented in environments that have fewer than three crew members during flight operations.

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Evaluating Stereo Displays for Manual Control

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The current study was conducted to evaluate the relative benefits of stereo presentation versus higher update rates for controlling simulated vehicle motion. Visual displays are used to convey critical control information to pilots of aircraft and space vehicles. Recent developments in display technology enable the use of stereo displays, but these displays incur significant costs. In addition to increasing the complexity of system hardware and software, stereo necessarily decreases the spatial or temporal resolution of the display, since the two required fields (one for each eye) must be interlaced temporally or spatially. In the past, analysis tools were developed to examine which visual cues are required to support manual control tasks. This year, we applied this tool to determine whether stereo displays improved operators' control of motion in depth (as in a docking task), given that stereo halves the update rate of the display.

The model of the depth control task is shown in Figure 1. It was previously demonstrated that stereo disparity provides a more useful cue for position than for motion, leading to the prediction that stereo would prove more useful when operators control vehicle rate (i.e., change in position) than acceleration (i.e., change in motion). In the experiments, pilots performed both kinds of control tasks while viewing either stereo or non-stereo displays at two different update rates.

Results indicated that pilots performed significantly better with stereo on the rate-control task, but gained no benefit from stereo on the